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Elastic properties of single crystalline $\text{LaSr}_2\text{Mn}_2\text{O}_7$

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We have grown single crystalline $\text{LaSr}_2\text{Mn}_2\text{O}_7$ by the floating-zone (FZ) method. Ultrasonic measurements have been performed to investigate the $d\gamma$ state in Mn ions, which is sensitive to elastic stress. Furthermore, the magnetization and the electric resistivity measurements have been performed, too. A pronounced anomaly has been observed around $T_{co} = 220$ K in all elastic constants c_{11} , c_{33} , c_{44} , c_{66} and $(c_{11}-c_{12})/2$. In particular, the elastic constant $(c_{11}-c_{12})/2$ exhibits a remarkable softening around T_{co} , implying a degeneracy of $d\gamma$ orbital state. Furthermore, we found that the ultrasonic echo signal became shaky gradually below 190 K with decreasing temperatures due to the strong increase of the ultrasonic attenuation, probably associated with the too large change of its sound velocity or elastic domain. However, the ultrasonic echo signal made a recovery below 120 K in all elastic constants, in which another magnetic ordering occurs around 140 K.